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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE RECEIVED 78

Applicant: JOHN H COLEMAN  
 Serial No: 857,690  
 Filed: December 5, 1977  
 For: METHOD OF FORMING SEMICONDUCTING MATERIALS AND BARRIERS

#3/16  
 GROUP 160  
 Art Unit 162  
 Examiner  
 J. H. Newsome

Hon. Commissioner of Patents & Trademarks  
 Washington, D.C., 20231

Sir:

In response to the office action dated March 2, 1978, being paper no. 2 in this case, please amend the above identified application as follows:

IN THE CLAIMS

Claim 1, line 1, after "producing" delete:--"semiconductor coating"-- and add: --"film"--.

line 5, after "to" delete: --"the"-- and add: --"said"--.

line 6, before "to" add: --"and controlling said pressure"--.

line 7, 8, after "surface" delete: --"and controlling said pressure and said electric field"--.

line 8, 9, after "uniform" delete: --"semiconductor coating"-- and add: --"film"--.

Claim 2, line 1, delete: --"Claim 1"-- and add: --"In the method of Claim 1"--.

lines 1, 2, after "said" delete: --"semiconductor has a dark resistivity between  $10^6$  and  $10^{12}$  ohm-cm"-- and add: --"film is a semiconductor"--.

Claim 3, line 1, delete: --"Claim 1"-- and add: --"In the method of Claim 1"--.

line 2, delete: --"semiconductor coating" -- and add:

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- Claim 4, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.
- Claim 5, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.
- Claim 6, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.  
line 1, after "said" add: --"fringing"--.
- Claim 7, line 1, delete: --"Claim 1" -- and insert: --"In the method of Claim 1"--.  
lines 2, 3, delete: --"In the weaker components of said"-- and insert: --"in said fringing"--.
- Claim 8, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.
- Claim 9, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.  
line 2, delete: --"coating"-- and insert: --"film"--.
- Claim 10, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.  
line 2, delete: --"coating"-- and insert: --"film"--.
- Claim 11, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.  
line 1, delete: --"p-n"-- and insert: --"p-i-n"--.
- Claim 12, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.  
line 2, delete: --"coating"-- and insert: --"film"--.
- Claim 13, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.  
line 2, delete: --"coating"-- and insert: --"film"--.
- Claim 14, line 1, delete: --"Claim 1"-- and insert: --"In the method of Claim 2"--.
- Claims 15, 16, 17, line 1, delete: --"Claim 14"-- and insert: --"In the method of Claim 14"--.

Claims 18-25, 28-29, 32-35, 37, 40, delete: --"Claim"-- and  
insert: --"In the method of  
Claim"--.

Claim 26, line 1, delete: --"Claim 1"-- and insert: --"In the  
method of Claim 2"--.

line 1, between "glass coated" insert: --" ^ "--  
pointing to: --"and is"--.

Claim 27, line 1, delete: --"Claim 1"-- and insert: --"In the  
method of Claim 2"--.

Claim 30, line 1, before "semiconductor" insert: --"amorphous"--.

Claim 31, line 3, after "nitrogen" insert: --"and hydrogen"--.

Claim 39, line 1, delete --"semiconductor coating"-- and insert:  
--"film"--.

line 5, before "electric field" insert: --"fringing"--.  
delete: --"the"-- and insert: --"said"--.

line 6, before "to maintain" insert: --"and controlling  
said pressure"--.

line 7, 8, delete: --"and controlling said pressure and  
said electric field"--.

line 8, delete: --"semiconducting coating"-- and  
insert: --"film"--.

Claim 40, line 1, delete: --"Claim 29"-- and insert: --"In the  
apparatus of Claim 39"--.

Please add the following claims:

Claim 41: The method of producing a film on the surface of a  
substrate spaced across a portion of an electrode  
structure by a separation in an evacuated enclosure  
comprising the steps of introducing a gaseous material

at sub-atmospheric pressure in the region of said substrate surface, applying ~~an~~ *non-uniform* electric field to said substrate surface to maintain a glow discharge in the region adjacent said substrate surface outside said separation to produce a substantially uniform film on said substrate surface.

Claim 42: In the method of Claim 1 in which said ~~fringing field~~ *non-uniform electric field* is applied by means of an elongated planar member positioned substantially perpendicular to the tangent plane of said substrate surface.

Claim 43: In the method of Claim 1 in which said ~~fringing field~~ *non-uniform electric field* is applied by means of an array of elongated cylindrical members positioned substantially perpendicular to the tangent plane of said substrate surface.

Claim 44: In the method of Claim 1 in which said ~~fringing field~~ *non-uniform electric field* is applied by means of an elongated planar member positioned on the opposite side of said substrate surface.

Claim 45: The method of producing a semiconducting film on the surface of a substrate in an evacuated enclosure comprising ionizing a gaseous, film-forming material at sub-atmospheric pressure, applying a ~~fringing~~ *non-uniform* electric field to said substrate surface and controlling said pressure to collect said ions on said surface to produce a uniform semiconducting film on said surface.

Claim 46: In the method of Claim 2 in which said gaseous material contains semiconductor film-forming vapor from a thermal source.

Claim 47: In the method of Claim 2 in which said gaseous material contains semiconductor film-forming material sputtered from a solid source.

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Claim 48: In the method of Claim 1 in which said substrate is moved relative to said ~~applying electric field~~ *non-uniform electric field*.

Claim 49: A semiconductor device comprising: a body of amorphous silicon fabricated by a glow discharge in silane having a nitride surface layer; and a metallic region on said surface providing a surface barrier junction at the interface of said metallic region and said body which is capable of generating a space charge region in said body.

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Claim 50: A semiconductor device comprising: a body of amorphous silicon fabricated by a glow discharge in silane; and a metallic region on a surface of said body providing a surface barrier junction at the interface of said metallic region and said body which is capable of generating a space charge region in said body.

Claim 51: The semiconductor device of Claim 50 wherein said body is one micron or less in thickness and said metallic region is of a material having a work function of 4.5eV or greater such that the space charge region is capable of extending across all of said body.

Claim 52: The semiconductor device in accordance with Claim 50 further comprising an electrically conductive substrate on a surface of said body opposite said metallic region.

Claim 53: The semiconductor device in accordance with Claim 52 further comprising an electrode on a portion of a surface of said metallic region opposite said substrate.

Claim 54: The semiconductor device in accordance with Claim 50 wherein the amorphous silicon has an average density of localized states in the energy gap on the order of  $10^{17}/\text{cm}^3$  or less.

- Claim 55: The semiconductor device in accordance with Claim 50 wherein the amorphous silicon has a mobility for electrons of  $10^{-3}$  cm<sup>2</sup>/V-sec. or greater.
- Claim 56: The semiconductor device in accordance with Claim 50 wherein the amorphous silicon has a carrier lifetime on the order of  $10^{-7}$  sec. or greater.
- Claim 57: A semiconductor device comprises: a body of amorphous silicon fabricated by a glow discharge in silane with a semiconductor junction in said body.
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- Claim 58: The semiconductor device in accordance with Claim 57 wherein the amorphous silicon has a carrier lifetime on the order of  $10^{-7}$  sec. or greater.
- Claim 59: The semiconductor device of Claim 57 wherein said body comprises a first doped layer of one conductivity type spaced from a second doped layer of an opposite conductivity type with an "intrinsic" layer between and in contact with the first and second doped layers, such that there is a capability of a spaced charge region being provided in the "intrinsic" layer.
- Claim 60: The semiconductor device of Claim 59 wherein the intrinsic layer is on the order of one micron or less in thickness from said first doped layer to said second doped layer.
- Claim 61: The semiconductor device of Claim 60 further comprising: an electrically conductive substrate on a surface of said second doped layer opposite the intrinsic layer; and a solid radiation transmissive electrode of good electrical conductivity on a surface of said first doped layer opposite the intrinsic layer.
- Claim 62: The semiconductor device of Claim 57 wherein said body comprises a first doped layer of one conductivity type in contact with a second doped layer of an opposite

conductivity type having a P-N junction there-between.

Claim 63: The semiconductor device of Claim 62 comprising:

a third doped layer on a surface of said second doped layer opposite said P-N junction, the third doped layer of the same conductivity type and higher doping concentration as said second doped layer;

a solar radiation transmissive electrode of good electrical conductivity on a surface of said first doped layer opposite said P-N junction; and

an electrically conductive substrate on a surface of said third doped layer opposite said P-N junction.

IN THE DRAWINGS

Formal drawings replacing the informal drawings in accordance with Examiner's notice. During drafting, the following typographical errors were corrected by the draftsman to correspond with the Specifications which do not appear to constitute any material changes or new material:

Fig 5a, delete: --"91a" and insert: "93a".

in chamber G<sub>3</sub> insert: "80' ".

Fig 6, on crucible add: "52"

Fig 7, delete: "89" and insert: "89' "

~~Fig 8, delete: "123" and insert: "122"~~

~~delete: "127" and insert: "129"~~

~~delete: "124" and insert: "123"~~

IN THE SPECIFICATIONS

The following duplicate numbers and typographical errors relating to the figures are corrected as follows:

page 12, line 6, delete: "80" and insert: "80' "

line 19, after "region" delete: "66" and insert: "64"

page 16, last paragraph, after "source, delete: "89" and insert: "89' "

lines 11, 12, after crucible, delete: "56" and insert: "52".

lines 15, 17, after "plate", delete: "55" and insert "54".

page 5, last line, delete: "--guage"-- and insert: "--gauge"--

page 6, line 1, 4, delete: "--guage"-- and insert: "--gauge"--

page 5, last line, delete: "--evaluation"-- and insert: "--evacuation"--

REMARKS

The claims of this application have been rejected under 35 U.S.C. 103 on a combination of references as unpatentable over Carlson alone or in view of Hough. Two secondary references, Sterling et al and Fan, were made of record because they teach the deposition of amorphous silicon. The Examiner's position is respectfully traversed.

In the paragraphs below, the amendments to the claims and the new claims are discussed and they are explicitly related to language in the present Specifications. Also, each of the references cited are considered in turn and discussed in relationship to Applicant's invention. Applicant's claims, as amended, will be seen to clearly distinguish over each of the references and over any valid combination of these references. Furthermore, as Carlson's apparatus does not appear to provide a practical, industrial solution to production of film for devices, Carlson's claims were copied by Applicant for prosecution in the present case since support existed in the present application for these claims.

Referring now to claim 1 as amended above, the term "fringing --" was added to limit the type of electric field claimed to that actually used by the Applicant to produce films having more uniform properties over larger areas than those produced previously and to exclude the electric fields used in the prior art cited by the Examiner - which, as discussed below, are uniform electric fields. Support for the term "fringing" is found in the Specifications on page 11, lines 13-15; and the fringing configuration, itself, is illustrated schematically by the dashed lines labelled E in Figs 1, 3, 5b. A fringing electric field is involved with the central concept of all embodiments.

Referring again to claim 1, support in the Specification for rearranging the phrases to read:

--- "controlling said pressure to maintain a glow-discharge" ---.

is found on page 7, lines 1-6, in which you will note the wording:

--- "Next the pressure PG of silane is adjusted to position a diffuse discharge P in the region above plate 100" ---.

One preferred mode of operation covered in claim 6 - i.e. to maintain the glow-discharge within the "weaker field  $E_w$ " as described on page 14, line 8; page 7, line 5; and page 11, line 15; is dependent on amended claim 1.

Support for the -- "negative glow" -- wording of amended claim 7 is found on page 14, lines 7-10, and is illustrated by the symbol P in Fig 1, 3, 5b. Apparatus claim 39 was amended to limit the claim language in a similar manner to correspond with the wording of claim 1. Thus, the amended claims now define Applicant's new concepts and clearly distinguish the process from that of the prior art as discussed below.

In addition, new species claim 41-44 were added to cover the specific electrode geometries discussed in the specifications. Support in the specification for the language of new claim 41 may be found by referring again to page 14, lines 7-10, noting the language:

--- "for 1/2" separation d" ---

and by referring to Fig 5b where the symbol "d" illustrates the "separation" between the electrode and substrate. In addition, the "separation d" was illustrated in Fig 1 and discussed on page 7, line 4. Please note that these lines teach the concept included in the embodiment of claim 41 that the glow-discharge is

maintained outside the electrode-substrate "separation". The language in claim 41 is more restrictive than that in claim 1. Thus new claims 41-44 are subordinate to claim 1.

Please note that claims 1, 39, 41 relate broadly to "films" and are not limited to semiconductor films since some claims cover silicon nitride, (i.e. insulating films) and Examiner searched glow-discharge-deposited silicon nitride in addition to semi-conducting films of silicon in response to Applicant's claims. However, none of the art cited anticipated Applicant's process or apparatus.

Referring to new claim 45, the wording "fringing field" was incorporated to limit the language to the limitations in claim 1, but two distinct steps - ionizing and attracting - were provided to cover effects that occur during evaporation or sputtering as discussed in connection with Figs 6, 7. Species claims 46, 47 were added to cover the evaporation and sputtering embodiments and were made dependent on claim 2, thereby limiting new claims 45-48 to semiconductor films to attempt to remain well within the search made by the Examiner's references, which are discussed below.

Referring now to Examiner's reference D, US 4,064,521, Carlson's preferred apparatus shown in Fig 3 illustrates applying a uniform field between an electrode 36 and a substrate 12 - which have a parallel, planar geometry. In such geometry, controlling the pressure, as taught by Applicant, would have little or no effect since the discharge remains in the same position in the uniform field until the onset of streamers and sparks at the high pressure extreme or until the discharge is extinguished in the region of the substrate surface at the low pressure extreme where Applicant's process operates best.

Indeed, Carlson could not have stumbled upon Applicant's process since, as you will note by referring again to Fig 3, his substrate 12 rests on ceramic plate 38 which effectively shields the rear of the substrate 12 from the fringing field projected outside the electrode-substrate separation. Carlson showed no recognition of controlling the pressure which would have been required additionally to operate under Applicant's process conditions.

Furthermore, Carlson's three-electrode planar apparatus illustrated in Fig 4 has a similar uniform electric field between grid 149 and substrate 12 and the reverse side of substrate 12 is shielded by plate 138. Thus, both types of apparatus illustrated by Carlson are inoperative under conditions claimed by the amended claims and, in all processes and apparatus mentioned by Carlson, the necessary controls are lacking even if the electrode geometry was redesigned according to Applicant's teaching.

For example, referring to Carlson's specifications, the other examples of state-of-art glow-discharge apparatus suitable for producing the amorphous silicon material are given in column 5, lines 52-60 as RF glow-discharge systems, inductively and capacitatively coupled.

The first publication of hydrogenated amorphous silicon from silane described an inductively-coupled RF glow-discharge system. This paper, by Chittick, Alexander and Sterling, was referenced on page 1, second paragraph, of my present specification.

By referring to Chittick et al's paper, Examiner will observe that an external coil induces a glow-discharge in the gaseous material in a region upstream from the substrate, from which the ions diffuse to the substrate. It is well known that, in a RF

glow-discharge system, the electric field at the substrate is due to collection of the plasma-electrons - which are more mobile than the heavier positive ions. These electrons diffuse to the substrate surface and indiscriminately to all other surfaces in their path. The deposited charge develops a voltage on any insulating surface which collects the positive ions. The magnitude of the voltage developed depends on the value of the resistance of the surface at that instance. Thus, the parameters involved in an inductively-coupled, RF discharge are so significantly different from Applicant's process that the fringing field requirement and pressure-control-function essential to Applicant's process cannot be exercised without using Applicant's teaching.

Furthermore, in capacitatively-coupled, RF glow-discharge apparatus, the second example of Carlson's recommended systems, the electric power can be remotely coupled with external electrodes or can be applied internally - usually by parallel-planar electrodes. In either case the electrical field in the region of the substrate is the result of negative electric charge deposited by the electrons on the substrate itself, even when an external bias is applied to the substrate. None of Carlson's examples anticipate applying a fringing field and controlling the pressure as taught in Applicant's process.

Actually, Carlson's parallel planar electrodes of Figs 3, 4 are a rudimentary form of Applicant's electrodes illustrated in US Patent 3,068,510 which is referenced in Applicant's present specifications on page 3, line 2. Applicant is well aware of the difficulties involved in making uniform semiconducting material required for the devices covered by Carlson's issued claims. Although Carlson mentioned  $10\text{cm}^2$  areas in column 5, line 59 of Reference D, his publications present data from only  $1\text{-}2\text{cm}^2$  devices, such as the paper presented at the Atlanta Meeting

of the Electrochemical Society, Abstract No. 295, second paragraph page 791, referenced in Applicant's present specifications, page 2, last paragraph. In fact, Applicant's tests on parallel-planar glow-discharge systems more advanced than Carlson's examples raise serious doubts as to whether Carlson could have made the devices he claimed having sufficient area for commercial use in any of the glow-discharge apparatus he illustrated or which were available at the time of his filing date. In view of this, Applicant has, therefore, copied Carlson's claims as claims 50-63 for prosecution in the present application.

Regarding claims 50-63, Applicant respectfully requests that the Examiner make the Chittick, Alexander and Sterling paper mentioned above and referenced on page 1 in Background of the Invention of the present specifications, a formal reference in the present application. In particular, Examiner's attention is called to page 78, in the section titled "Electrical Resistivity" wherein a parallel-planar junction device was fabricated with aluminum electrodes applied to amorphous silicon material made from a glow-discharge in silane. Also, please refer to page 80 "Parallel Planar Structures" section and to Fig 8 which reveal that non-linear current-voltage characteristics were measured, suggesting Schottky-like surface barrier junction behavior as covered by Carlson's claim 1. Although the theoretical explanation presented by Chittick et al may not be correct, their amorphous silicon material formed from silane was essentially the same as Carlson's material and their apparatus was the same as that recommended by Carlson. Also, although their aluminum electrode is not the best "metallic region" for undoped amorphous silicon, their aluminum electrode does generate a voltage and a space charge region. Indeed, Carlson's later paper entitled "Properties of Amorphous Silicon and a-Si Solar Cells" published in RCA Review 38 (June 1977), pages 211-225,

presented data in Fig 7, page 219, that aluminum and all other metals tested formed a metal-semiconductor surface barrier junction and each metal gave an output voltage related to its work-function. Similar data was presented by Carlson in "Hydrogenated Amorphous Silicon - A Solar Cell Material" published in Thin Solid Films, 45 (1977) pages 43-46 and in "Amorphous Silicon Solar Cells" published in IEEE Transactions on Electron Devices, Vol. Ed. 24, No. 4 (April 1977), pages 449-453. Carlson's measurements confirm that glow-discharge-deposited amorphous silicon junctions behave as expected from solid-state theory - i.e. higher work-function metallic-surface barrier junctions generate higher voltages with n-type semiconductors. As seen on page 80, Chittick et al discovered that amorphous silicon can be doped n- or p-type. Thus, Chittick et al's paper described surface barrier junctions and p and n layers of amorphous silicon, and Carlson's paper shows a space charge region forms automatically when a metallic region is applied to the surface (unless heavily doped).

Examiner is requested to make UK patent 1,017,119 of Sterling et al, who was a co-author of Chittick, a formal reference since doping and p-n junctions were covered by claims of the type later allowed to Carlson.

Finally, the Examiner is requested to make a formal reference of another paper by Chittick relevant to Carlson's claims entitled "Properties of Glow-Discharge Deposited Amorphous Germanium and Silicon" published in Journal of Non-Crystalline Solids, Vol 3 (1970) pages 255-270. Please note on page 256 under "2.1 Deposition" that gold electrodes were evaporated on amorphous silicon made by a glow-discharge in silane. Gold, of course, has a work-function above 4.5 and is a preferred material in Carlson's claims. Both Chittick papers state that amorphous

silicon was produced from silane using an inductively-coupled RF discharge, which was stated in Carlson's patent to be a suitable source. Of course, as mentioned previously, the deposition of a film in inductively-coupled RF glow-discharge systems is controlled by internal charging of insulating surfaces and uniformity of deposition is limited to small areas. Therefore neither Chittick nor Carlson's process could provide production quantities of material suitable for devices covered in the allowed claims, whereas Applicant's process can provide quantities on a large, industrial scale.

Referring now to Examiner's reference A, U.S. 3,437,511, Hough illustrates concentric-cylinder electrode-substrate geometry. In cylindrical coordinates, the electrical field is uniform in direction between the electrode and substrate, and the strongest electric field occurs at the inner cylinder, i.e. at the substrate surface. Hough instructs in column 3, line 57:

--- "to form a cloud of such gas around the substrate  
10 within the energizing electrode 16" ---

Clearly Hough designed his apparatus for collection in the cylindrically-uniform electric field between the electrode and substrate and did not anticipate depositing in the fringing field projecting outside the electrode-substrate separation space; nor did he provide the necessary pressure controls for such operation. In any event, Hough's tube 14 would distort the fringing electric field and, consequently, interfere with the deposition of any film even if suitable pressure controls were added in accordance with Applicant's teaching.

Regarding Examiner's Reference C, U.S. 4,059,461, Fan converts an amorphous silicon film to a poly-crystalline film by rapidly heating the film with a laser. Such action would destroy the useful properties of amorphous silicon required for the

embodiments of the present application. Amorphous silicon has a substantial advantage over poly-crystalline film for large scale use since the amorphous structure has a significantly larger optical absorption coefficient -ironically . . . Fan uses . . . Fig 5 for facilitating its conversion. Thus, for example, in solar cells, an application of current commercial interest, a one micron amorphous film absorbs as many solar photons as a 50 or so micron poly-crystal wafer, thereby resulting in a substantial saving of material. Finally, Fan's laser heat-treatment above 350°C de-hydrogenates amorphous silicon and degrades its useful semiconducting properties.

Obviously Fan did not appreciate the advantages of amorphous silicon and his teachings were directed to altering its structure rather than to provide a process for producing amorphous material. Neither his amorphous silicon produced from solid silicon by evaporation or sputtering, nor his halo-silane feed-stock amorphous silicon would have produced the useful semiconducting properties without incorporating hydrogen as provided in the present invention. Further, Fan did not anticipate any of the teachings of the process or utilize apparatus of the present invention for making films.

Referring now to Examiner's reference B, U.S. 3,655,438, Sterling et al did produce a layer of silicon nitride in a glow-discharge as described in column 4, Examples 2, 3. Please note that in every case silane gas was mixed with ammonia gas in the glow-discharge. In Applicant's present claims 14, 30, 31 and the related dependent claim, the nitrogen-containing gas alone is subjected to a glow-discharge and the activated species applied to solid amorphous silicon deposited previously in a separate operation. In fact, as Applicant stated in the

present specification page 10, first paragraph:

--- "the gases, per se, do not form a film but combine with the coating 10, deposited previously" ---

Indeed, Applicant found that a mixture of silane plus ammonia deposited simultaneously on amorphous silicon in a MIS solar cell did not produce a significant output voltage. These results are surprising since glow-discharge-deposited silicon nitride is known to be a good insulator.

A possible explanation of these negative results with simultaneous deposition is that the silicon nitride layer is too thick for charge carriers to tunnel through and generate useful output voltage. Also, the resulting  $\text{Si}_x\text{N}_y\text{H}_z$  formed by the Sterling process and Applicant's process may be quite different stoichiometrically in composition. Applicant has not been able to quantify the composition as yet, although analytical techniques are under development which may unravel at least the XYZ ratio. For example, W. A. Lanford described recently in the Journal of Applied Physics 49 (April 78), pages 2473-2477, a useful analytical technique for determining composition of silicon nitride produced from co-deposition of silane and ammonia. He also shows that CVD and glow-discharge-deposited silicon nitride are different.

Claims 14, 30, 31 were amended to limit the claims to applying the activated nitrogen to amorphous semiconductors. Claim 49 was added to cover a MIS device, such as illustrated in Fig 2a, made by glow-discharge in nitrogen-hydrogen gases.

Thus, there are presently offered the original process and apparatus claims amended to define clearly Applicant's novel improvements over the prior art. New claims were added with all the limitations of the generic claim to cover the specific

apparatus described and illustrated and to cover the addition of material by evaporation and sputtering. In addition, claims relating to devices made from amorphous silicon were copied from the Carlson patent of reference, and a device claim covering Applicant's new MIS structure was added.

Applicant wishes to express his appreciation for Examiner's courteous advice during a personal interview and for directing Applicant's attention to the appropriate Federal Regulations governing discovery of failure to disclose relevant prior art in an issued patent. At the suggestion of the Examiner, Applicant has consulted Counsel regarding the new amendments to the claims and on the implications of provoking an interference - although Applicant continues to act as his own attorney of record.

Also, Applicant has brought to the Commissioner's attention in a separate letter the fact that, although Carlson was aware of the Chittick et al reference discussed above, his Attorney did not disclose the paper in the specifications and the Examiner did not make the paper a reference. Carlson's earliest publication, "Amorphous Silicon Solar Cell", in Applied Physics Letters, Vol 28 (June 1, 1976), pages 671-673, credited Chittick et al with the "first studies", and Carlson's later papers proved that Chittick's metallic-surface-barrier-junction devices and p, n layers with electrodes operated identically to those covered many years later by claims issued to Carlson. A copy of my letter was sent to the RCA Patent Department, to which Carlson's patent is assigned.

Respectfully,

By

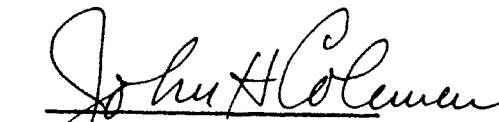
*John H. Coleman*  
John H. Coleman  
Applicant

Dated: May 18, 1978  
P.O. Box 548,  
Locust Valley, N.Y., 11560

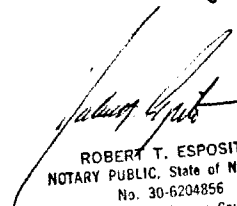
Encl: Formal Drawings  
Check in payment for 23 added claims (5 independent).



I hereby attest that all unsigned alterations were made prior to signing the Oath and Declaration which was submitted with the original application.

  
John H. Coleman

Dated May 19, 1978

  
ROBERT T. ESPOSITO  
NOTARY PUBLIC, State of New York  
No. 30-6204856  
Qualified in Nassau County  
Commission Expires March 30, 19 80